

Taxonomic Status of *Rhacophorus taronensis* Smith, 1940

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Polypedates gongshanensis (Yang and Su, 1984), described as endemic to the Gaoligong Mountains of western Yunnan Province, China, is demonstrated to be a junior synonym of *Rhacophorus taronensis* Smith, 1940, the latter known only from the type specimen collected in northern Myanmar. This poorly known species is revisited, and new data derived from comparisons of the original descriptions, examinations of the type specimens of *R. taronensis* and *P. gongshanensis*, and newly acquired specimens from Myanmar and China are presented.

Smith (1940)¹ described a new species of *Rhacophorus* based on a single specimen (BMNH 1947.2.8.17) collected by R. Kaulback in the north of Myanmar (Patsarlamdam, Taron Valley; N 27°43', E 98°10') on 01 June 1939. He states that this new species (*R. taronensis*) is related to *R. bimaculatus* but differs by having less extensive webbing of the fingers, the absence of a dermal projection on the heel, and different coloration. He gives a snout-vent length of 78 mm and also presents a drawing of the right hand (Smith 1940, fig. 3). Since then, no new specimens of *R. taronensis* have been reported.

Yang and Su (1984)² described a new species of *Rhacophorus* from the southern Gaoligong Mountains of western Yunnan Province, China. They compared their specimens only to *Rhacophorus feae* (now *Polypedates feae* fide Frost 2002), probably due to the similar brown line extending from the tip of the snout to behind the tympanum that is present in both their specimens and *R. feae*. Their specimens differed from *R. feae* by the webbing of the first and second fingers being restricted to the base and only one-third webbing between the remaining fingers; the heels overlapping when the legs are at right angles to the body; and by the presence of creamy-colored spots on the flank and inner and outer sides of the thigh. Based on these differences, they concluded that these specimens represented a new species, *R. gongshanensis*, believed to be restricted to the

¹ Original description (Smith 1940): "Vomerine teeth in strong, almost transverse, groups, commencing at the inner margin of the choanae. Head broader than long, much depressed; snout rounded, scarcely projecting beyond the mouth, shorter than the eye; canthus rostralis distinct; loreal region oblique, feebly concave; nostril a little nearer the tip of the snout than the eye, nearly as broad as the interorbital space, broader than the upper eyelid; tympanum very distinct, 4/5 the diameter of the eye, close to it. Outer three fingers with very large discs, which are as broad as long and as large as the tympanum; more than half webbed, the membrane reaching the disc of the 4th finger and that of the 2nd on the outer side; toes fully webbed, their discs smaller than those of the fingers; the tibio-tarsal articulation reaches to between the eye and the tip of the snout; subarticular tubercles of both fingers and toes strongly developed; a short oval inner metatarsal tubercle; no outer. Skin smooth above, that of the belly and hinder part of the thighs coarsely granulate. A dermal fringe, feebly distinct, on the outer side of the fore-arm, tarsus and foot. Bluish above, green in life, with small black spots; lower parts whitish, thickly speckled with dark grey; hinder part of thighs black with white spots. From snout to vent 78 mm."

Gaoligong Mountains. Subsequently, Fei, Ye, and Huang (1990) placed *R. gongshanensis* in the genus *Polypedates* without explanation.

In the process of identifying specimens of *Rhacophorus* collected in northern Myanmar in 2002 by the Myanmar Herpetological Survey Project (a collaborative project of the California Academy of Sciences, Smithsonian Institution, and the Nature and Wildlife Conservation Division, Forest Department, Myanmar), the holotype of *R. taronensis* (BMNH 1947.2.8.17, re-catalogued from BM 1940.6.1.39; Figs. 1A, C, E) was examined. It was immediately evident that the holotype was similar in appearance to specimens of *P. gongshanensis* from Baoshan Prefecture, Yunnan Province, China, collected by a California Academy of Sciences (CAS) and Kunming Institute of Zoology (KIZ) field expedition in 2003.

METHODS AND MATERIALS

In order to determine whether *R. taronensis* and *P. gongshanensis* are conspecific, the holotypes of *R. taronensis* and *P. gongshanensis* (KIZ 810485; Figs. 1B, D, F) were examined and compared to each other and to the original descriptions. In addition, they were compared with a paratype of *P. gongshanensis* (KIZ 810555) and newly collected specimens from Myanmar.

Specimens recently collected in Myanmar are housed in the collections of the Department of Herpetology, CAS and the Myanmar Biodiversity Museum (MBM), Hlawga, Myanmar. Newly collected specimens from Baoshan Prefecture, China (GLGS field numbers in materials examined section below), are as yet not available for measurements, but eventually they will be housed in the

² Literal translation of original description in Chinese (Yang and Su 1984) — “The body is medium in size, the largest among the 6 male specimens is only 72.2 mm long, the only female specimen is 81.5 mm long. The head is slightly longer than wide in males, but wider than long in the female; the rostrum sharply angles downward from the nostril forward, the canthus rostralis is obvious, the loreal region slants slightly outward, the surface of the loreal region is concave; the nostrils are located midway between the tip of the snout and eyes; the internarial distance is shorter than the interorbital distance; the top of head is flat; the tympanum is elliptical and close to the eye, with a vertical diameter $\frac{1}{2}$ of the diameter of the eye, and close in size to the disc of the third finger; the back of the tongue has a deep notch; vomerine teeth are not curved into an arch, the lateral end is slightly beyond the anterior angle of the internal nares, slightly inclined caudally but does not pass the posterior edge of the internal nares.

“The forearm of the male frog is strong, that of the female is slightly weaker, the length of the forearm and hand is slightly beyond half of the body. Fingers are flattened, and rank according to size from big to small, as 3, 4, 2, 1. The disc is wide and straight at terminal end, with a transverse groove at the tip. The disc of the first finger is small; the second, third and fourth fingers are approximately $\frac{1}{2}$ webbed, the second finger is webbed to the subarticular tubercle, the third and fourth fingers are webbed to the distal end of the subarticular tubercle, the first and second fingers are only webbed at the base; the inner edge of the first finger and outer edges of the second and third fingers with obvious marginal webbing; the tubercles at the distal end of the third and fourth fingers are bigger than those at the proximal end; the inner edge of the first finger is enlarged at the base in a transverse direction. The hind limbs are 1.5 times that of the body size, the specimen KIZ 810485 is 1.7 times, tibiotarsal articulation reaches to the middle or anterior edge of eyes, the left and right heels overlap; feet are shorter than the tibia (6 males), but reverse for the female; webbing on the toes are relatively well developed to the base of the disc, only the fourth toe webbed to the distal subarticular tubercle; the subarticular tubercles are small and round, inner metatarsal tubercle is small, flat and elliptical, no outer metatarsal tubercle.

“The male frog is dotted with white asperities on the dorsal aspect of the body and hind limbs, but the female frog with fewer asperities than the male; dense flat areolation on the ventral surface, the areolation on the lower jaw, throat, and pectoral region is smaller than other areas, the front of the lower jaw of the female frog is smooth without tubercles, the supratympanic fold is linear but slopes slightly backward.

“In life, the pupil is a horizontal ellipse, blue-black, iris is greenish yellow. Upper surface of head, body, and the four limbs is grass-green, with sparsely scattered small brown spots. The flank and inner and outer side of thigh with many creamy yellow spots, big or small, with dark reddish brown to purple edges. The canthus rostralis, lateral edge of eyelid, and supratympanic fold are light brown. The anterior half of the fingers and toes are violet on dorsum, the posterior half remains grass-green. The supraocular region, from the tibiotarsal articulation to the base of the fifth toe, and outer side of forearm to the base of fourth finger with a yellowish fine linear dermal ridge. Ventral surface light brown to purple, with scattered deep dark spots.”

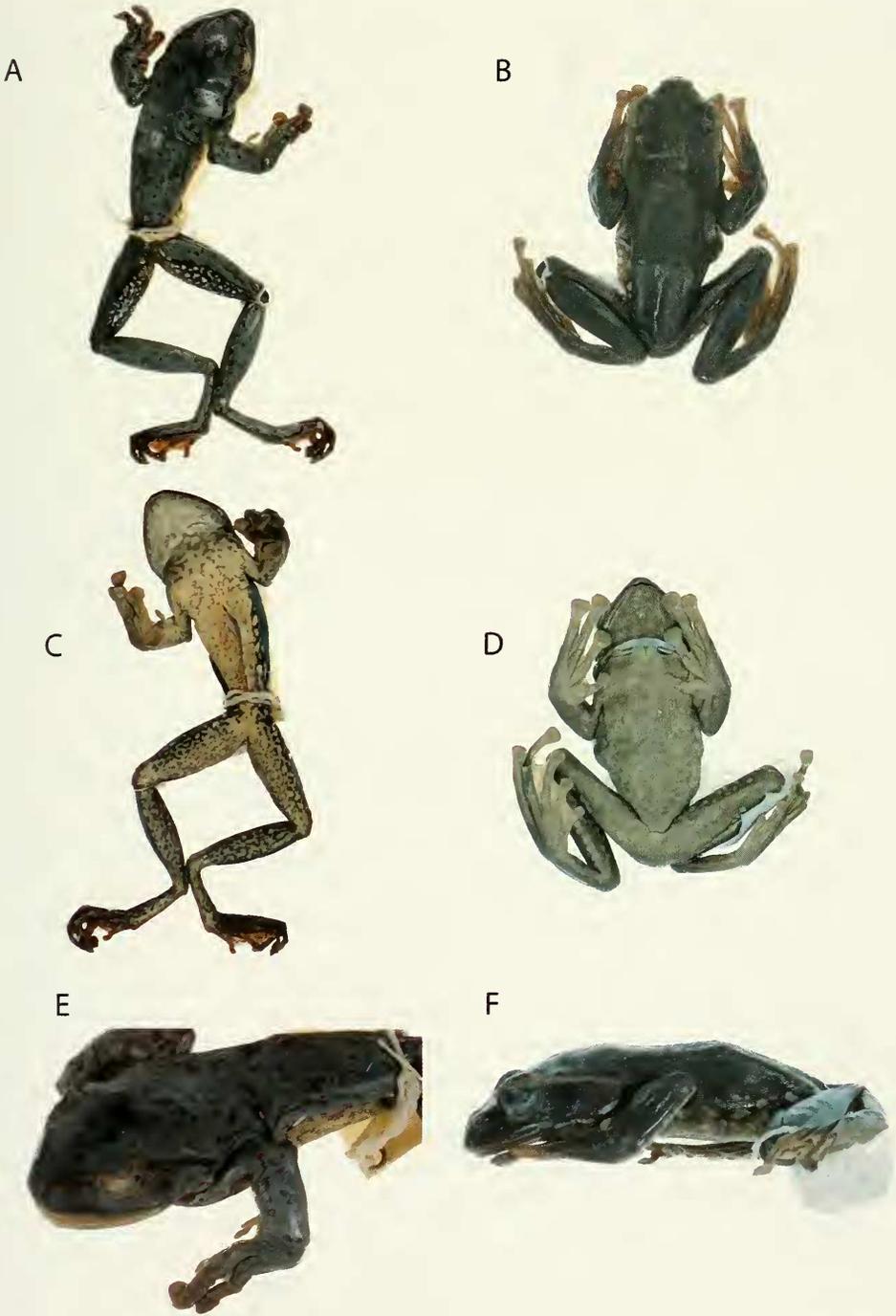


FIGURE 1. Dorsal, ventral, and lateral views respectively of the holotype (BMNH 1947.2.8.17) of *Rhacophorus taronensis* (A, C, E) and the holotype (KIZ 810485) of *Polypedates gongshanensis* (B, D, F).

collection of the Department of Herpetology, CAS and the Department of Herpetology, KIZ. They have been included to report locality data. After tissues were removed from the recently collected specimens (Myanmar and China), the specimens were fixed in 10% buffered formalin before being transferred to 70% ethanol. Latitude and longitude were recorded with a Garmin 12 GPS (WGS84).

Sex was determined by the presence or absence of vocal apertures, or the presence or absence of eggs within the abdominal cavity. Measurements were taken using dial calipers to the nearest 0.1 mm as follows: snout-vent length (SVL, from tip of snout to vent); head length (HL, from tip of snout to hind border of angle of jaw); head width (HW, width of head at its widest point); internarial distance (IND, distance between nares); interorbital distance (IOD, minimum distance between upper eyelids); upper eyelid width (UEW, maximum upper eyelid width); snout length (SL, from anterior border of eye to tip of snout); eye diameter (ED, horizontal length between orbital borders of eyes); distance from nostril to eye (DNE, from nostril to anterior border of eye); tympanum diameter (TD, greatest diameter); forelimb length (FLL, from elbow to tip of third finger); first finger length (FFL, from palmer end of inner metacarpal tubercle to tip of finger); third finger length (TFL, from base point between third and fourth fingers to tip of finger); hand length (HAL, from base of outer palmer tubercle to tip of third finger); thigh length (THL, from vent to knee); tibia length (TIL, from knee to foot); foot length (FL, from proximal end of metatarsal tubercle to tip of fourth toe); fourth toe length (FTL, from distal end of third subarticular tubercle to tip of toe); inner metatarsal length (IML, at point of greatest length); width of disk of third finger (3FDW, greatest horizontal width); and width of disk of fourth toe (4TDW, greatest horizontal width).

RESULTS

COMPARISON OF TYPES.— The holotype of *R. taronensis* (female) is similar to the holotype of *P. gongshanensis* (male) in shape, color, and pattern. However, the holotype of *R. taronensis* is longer (SVL 76.6) than the holotype of *P. gongshanensis* (SVL 70.5), the head is wider than long (versus longer than wide in holotype of *P. gongshanensis*), the nostrils are nearer to the tip of the snout than the eyes (versus midway between eye and tip of snout in holotype of *P. gongshanensis*), and the third finger is longer with a wider disc (versus shorter with a narrower disc in holotype of *P. gongshanensis*). The SVL is also longer and the head wider than long for the female paratype of *P. gongshanensis* (CIB 810723; referred to as the allotype in Yang and Su) and a female specimen (CAS 224382) in this study, indicating that these are sexually dimorphic characters. The length of the third finger and width of the disc of third finger are not mentioned for the female paratype of *P. gongshanensis* in Yang and Su (1984) but in the aforementioned female specimen in this study are similar to the holotype for *R. taronensis* and different from the male specimens (Table 1), indicating that these may also be sexually dimorphic characters. The relative location of the nostrils was also nearer to the tip of the snout in the aforementioned female specimen and most of the male specimens, but closer to the eyes in two male specimens (KIZ 810555, CAS 224371) suggesting that this character is not sexually dimorphic.

To detect whether other species of *Rhacophorus* also possess the aforementioned apparent sexually dimorphic characters, specimens of *R. owstoni* were measured for SVL, HL, HW, TFL, and 3FDW. All female specimens ($N = 14$) were larger (SVL $\bar{x} = 58.93$, $\sigma = 4.13$) than the male specimens ($N = 12$; SVL $\bar{x} = 46.86$, $\sigma = 2.21$). Also, several but not all female specimens possessed a head slightly wider (HW $\bar{x} = 22.46$, $\sigma = 1.56$) than long (HL $\bar{x} = 22.28$, $\sigma = 1.13$), whereas, all male specimens possessed a head slightly longer (HL $\bar{x} = 17.92$, $\sigma = 0.80$) than wide (HW $\bar{x} = 17.47$, $\sigma = 0.76$). Also, the length of the third finger and the width of the disc of the third finger were on average respectively longer and wider in the female specimens (TFL $\bar{x} = 9.45$, $\sigma = 0.73$,

TABLE 1. Measurements of the holotype and newly collected specimens of *Rhacophorus taronensis* and the holotype and a paratype of *Polypedates gongshanensis*. Top values for holotypes are original measurements in Smith (1940) and Yang and Su (1984).

	sex	SVL	HL	HW	IND	IOD	UEW	SL	ED	DNE	TD	FLL	FFL	TFL	HAL	THL	TIL	FL	FTL	IML	3FDW	4TDW	
BMNH 1947.2.8.17		78																					
(holotype)	F	76.6	24.4	26.8	6.4	7.1	5.6	10.7	9.6	6.2	5.6	42.6	13.7	19.6	26.3	34.9	39.7	35.2	17.2	4.2	5.6	3.6	
CAS 224382	F	73.1	24.5	25.3	5.9	8.4	7.2	11	8.3	6.4	5	40.9	12.9	17.1	25.7	39.9	36.4	33.5	17.2	3.3	5.9	4	
Average		74.9	24.5	26.1	6.1	7.7	6.4	10.9	8.9	6.3	5.3	41.7	13.3	18.3	26	37.4	38.1	34.4	17.2	3.8	5.8	3.8	
Ratio of SVL			32.7	34.8	8.1	10.3	8.5	14.6	11.9	8.4	7.1	55.7	17.8	24.4	34.7	49.9	50.9	45.9	23	5.1	7.7	5.1	
KIZ 810485		69	25	24.5	7.8	8.5	6.8	12	9.5		4.9	40			27	35.2		34				5	
(holotype)	M	70.5	23.5	23.1	6.4	7.6	6.4	11.2	8.6	5.5	5.5	40.4	12.2	16.8	25.3	35.1	34.6	33.9	17.3	3	5	3.8	
CAS 224371	M	67.7	24.2	22.8	6.5	6.8	4.7	11.8	7.9	5.7	5.1	35.7	10.3	14.2	20.6	32.6	29.5	27.1	13.3	3.3	4.3	3.7	
CAS 224377	M	62.4	22.1	20.7	5.3	6.3	5.8	10.5	7.6	5.9	4.5	34.2	9.8	13.5	20.7	31.6	29.6	27.6	13.7	2.6	3.7	2.7	
KIZ 810555																							
(paratype)	M	61.9	21.6	21.3	6.5	6.9	5.1	10	7.3	5.1	5.2	35.2	10.7	15.3	21.8	32.9	31.1	29.7	13.9	3.2	4.5	3.3	
CAS 224379	M	60.5	21.3	19.8	5.5	7.5	5.3	9.9	8	5.9	4.7	34.1	9.9	13.4	22.1	32.8	30.7	28.2	14	1.9	4.2	3.1	
MBM-JBS 11793																							
(holotype)	M	60.5	20	19.4	4.5	6.5	4.9	9.4	6.8	5.5	4.6	31.5	9.5	12.7	19.3	30.5	28.1	26.1	13.1	2.8	3.6	2.4	
CAS 224373	M	59.7	20.9	20.3	5.2	5.8	5	9.9	7.6	5.5	4	33.7	9.9	13.5	20.4	30.3	29.8	26.4	14.1	2.5	3.7	3	
CAS 224372	M	59.2	20.3	19.3	4.8	6.4	4.6	9.6	6.9	5.4	4.5	30.7	9.9	12.2	18.8	29.9	27.6	25.8	13	1.9	3.4	2.9	
CAS 224370	M	57.4	20.1	19.7	5	5.9	4.6	9.4	6.4	5.9	4.7	31.9	9.6	13.1	19.9	29.9	26.8	27.1	13.5	2.4	4.2	3.2	
CAS 224369	M	55.7	19.1	18.6	4.7	6.3	4.4	8.8	6.8	4.7	3.9	28.3	8.6	11.8	18.5	28.1	27.7	23.1	11.5	2.4	2.8	1.8	
Average		61.5	21.3	20.5	5.4	6.6	5.1	10	7.4	5.5	4.7	33.6	10	13.6	20.7	31.4	29.5	27.5	13.7	2.6	3.9	3	
Ratio of SVL			34.6	33.3	8.7	10.7	8.3	16.2	12	8.9	7.6	54.6	16.2	22.1	33.6	51.1	47.9	44.7	22.2	4.2	6.3	4.9	

ratio to SVL 0.20; 3FDW \bar{x} = 2.59, σ = 0.32, ratio to SVL 0.06) than male specimens (TFL \bar{x} = 12.70, σ = 1.16, ratio to SVL 0.22; 3FDW \bar{x} = 3.88, σ = 0.47, ratio to SVL 0.07), though these differences were more pronounced in the larger females, indicating that they may merely be ontogenetic.

Most of the characters given in the description by Yang and Su (1984) and Smith (1940) are consistent with both holotypes of *R. taronensis* and *P. gongshanensis*, with the following exceptions: (1) the position of the tibiotarsal articulation and the amount of webbing between the fingers for both the holotypes of *R. taronensis* and *P. gongshanensis* differ from the description by Yang and Su (1984) and more closely resemble the description in Smith (1940) in that the tibiotarsal articulation reaches to between the eye and end of the snout and the fingers are more than $\frac{1}{2}$ webbed; (2) the relative size of the tympanum and amount of webbing on the toes in both the holotypes of *P. gongshanensis* and *R. taronensis* differ from the description by Smith (1940) and more closely resemble the description in Yang and Su (1984) in that the tympanum is only slightly over half the diameter of the eye (Table 1) instead of $\frac{1}{3}$ th, and the toes are not fully webbed but reach only to the distal subarticular tubercle on the fourth toe; and (3) the holotype of *R. taronensis* is smaller than the reported size of the female paratype of *P. gongshanensis* by 3.5 mm (from Smith, 1940) or 4.9 mm (measurements taken in this study).

Measurements of all specimens examined are given in Table 1. These measurements differ slightly from those given in Yang and Su (1984) for the holotype of *P. gongshanensis* (greatest dif-

ference being 1.7 mm for hand length), and given in Smith (1940) for the holotype of *R. taronensis* (a smaller snout-vent length in this study). Measurements of the holotype of *R. taronensis* and the holotype and a paratype of *P. gongshanensis* are generally smaller than those reported in Yang and Su (1984) and Smith (1940). This may be due to shrinkage of the type specimens between measurements or different standards used in measuring. The nine specimens newly collected from Myanmar are on average smaller than those collected by Yang and Su (1984). However, the ratios of average measurements of each structure to average snout-vent length for the males are similar between the Yang and Su (1984) study and this study.

VARIATION.— Further observations were made on specimens newly collected from Myanmar. On several specimens (CAS 224370–224371, 224382, 224397, MBM-JBS 11793; Joseph B. Slowinski field number to be deposited in the MBM) the spotting on the flanks is white, more reticulate, and continues onto the ventral surface (Fig. 2). The brown spotting on the back may be very extensive (CAS 224371, 224377, MBM-JBS 11793) (Fig. 2) or absent (CAS 224369–224370, 224379).



FIGURE 2. From a color transparency of *Rhacophorus taronensis* (MBM-JBS 11793).

The discs on the fingers of the females are relatively larger than those of males but the snout lengths are relatively shorter. The rostrum of some specimens (CAS 224371–224372, 224377) is spatulate in form, from the nostril to the tip of the snout. All specimens have two strong brown dorsolateral lines that bifurcate at the tip of the snout and continue along the canthus rostralis, lateral edge of eyelid, supratympanic fold, and terminating behind the insertion of the forelimb (Fig. 2).

The preceding data demonstrate that the two types are the same species. Variation between the types and the other specimens in this study can be attributed to sexual dimorphism and normal ranges of differences within a species. *Polypedates gongshanensis* is, thus, a subjective junior synonym of *R. taronensis*.

DISTRIBUTION.— Based on records for the type specimens and recent collections in both China and Myanmar, at present, *R. taronensis* occurs only in the mountainous regions of the northern portion of Kachin State, Myanmar and to the south in Baoshan Prefecture, Yunnan Province, China (Fig. 3). Fei (1999) gives a distribution for *P. gongshanensis* extending from Baoshan Prefecture north along the Chinese side of the China-Myanmar border into Gongshan County, Nujiang Prefecture, indicating that this species occurs throughout the border regions of China and Myanmar. However, this distribution has not been confirmed by voucher specimens or recent surveys in these areas.

MATERIAL EXAMINED.— BMNH 1947.2.8.17, holotype of *R. taronensis*, Myanmar, Patsarladam, Taron Valley; 27°43'N, 98°10'E; CAS 224369–224372, MBM-JBS 11793, Myanmar, Kachin State, Putao District, Nagmung Township, Hkakabo Razi National Park, Nga War Village, 27°49'44.1"N, 97°45'59.3"E; CAS 224377, 224379, 224382, Myanmar, Kachin State, Putao District Nagmung Township, Hkakabo Razi National Park, Nga War Village, 27°49'04.1"N, 97°46'41.3"E; KIZ 810485, holotype of *Polypedates gongshanensis*, and 810555, paratype, China,

Yunnan Province, Baoshan Prefecture, Pumanshao; Gaoligongshan (GLGS) field numbers to be deposited in the CAS and KIZ. GLGS 1038–1039, 1047, 1049–1050, 1059–1063, 1065–1068, 1070–1079, China, Yunnan Province, Baoshan Prefecture, Tengchong County, Xiao Di Fang Village, 24°52'12.2"N, 98°45'13.4"E; *Rhacophorus owstoni*, CAS 211426–211447, 211449–211452, Japan, Okinawa Prefecture, Ryukyu Islands, Iriomote Island.

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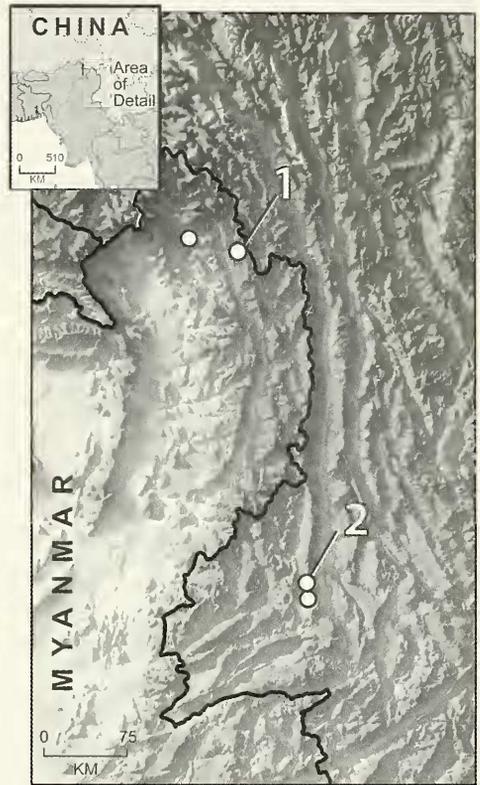


FIGURE 3. Map of known localities of *Rhacophorus taronensis* based on specimens used in this study. The type localities for *R. taronensis* and *P. gongshanensis* are indicated by the numbers 1 and 2 respectively.

LITERATURE CITED

- FEI, L. 1999. *Atlas of Amphibians of China*. Publishing House for Scientific and Technological Literature, Hunan, 432 pp.
- FEI, L., C-G. YE, AND Y-Z. HUANG. 1990. *Key to Chinese Amphibians*. Publishing House for Scientific and Technological Literature, Chongqing, 364 pp.
- FROST, D.H. 2002. *Amphibian Species of the World: an online reference V2.21* (July 15, 2002). Electronic database available at: <http://research.amnh.org/herpetology/amphibian/index.html>.
- SMITH, M.A. 1940. The amphibians and reptiles obtained by Mr. Ronald Kaulback in upper Burma. *Records of the Indian Museum* 42:465–486.
- YANG, D-T., AND C-G. SU. 1984. *Rhacophorus gongshanensis*, a new species of flying frog from the Hengduan Mountains. *Acta Herpetologica Sinica* 3:51–53.